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Detailed project report for installation of gasifier system for village electrification (Village Sinapali, Komna District, Nuapara)

Prepared for **Orissa Renewable Energy Development Agency, Orissa**

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Part I: Project Information

1	Title of the project	Electrification of Sinapali Village, Komna Block, Distt.Nuapara, Orissa
2	Organization	Orissa Renewable Energy Development Agency
3	End User	Inhabitants of Sinapali village
4	Name of organizations jointly participating in the project	▪ Orissa Renewable Energy Development Agency ▪ Tata Energy Research Institute (TERI) ▪ Kurumpuri Grama Panchayat ▪ Village Energy Management Committee ▪ Divisional Forest Office (DFO)
5	Name & contact address	Mr A K Choudhary Project Director UNDP-DESI Development Project Office Komna Tel:066-7944815 Fax: 580368
6	Summary of project	The project aims to demonstrate a sustainable model for generation and supply of electricity using local biomass resource. The village site proposed for the project is one of the remote/ difficult-unelectrified villages of Komna block. The proposed project aims to supply electricity to 94 households of the village. Initially the project will supply electricity for domestic lighting/street lighting purposes in the evening hours. In future, it is expected that village will use the power for possible livelihood income generating activities
7	Duration of the project	24 months
8	Total budget outlay	Rs.17,20,000/-

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Background and context

Under the framework of country co-operation the UNDP has sanctioned a project titled `Decentralized rural Energy Systems for the Integrated Development of Komna block, Nuapara District of State of Orissa', through the Orissa Renewable Energy Development Agency (OREDA). The main emphasis of the project is on disseminating community-managed, community-owned decentralized energy interventions. The programme aims to disseminate renewable energy technologies/devices for individual and community use. It envisages installation of community-based energy system such as biomass gasifiers, large biogas plants, solar PV power plants, etc. for demonstration. The programme further proposes to institutionalize operation and maintenance networks, within the community. The activities pertaining to meet the project objectives are broadly categorized into following:

- Rural electrification
- Forestry
- Renewable energy programmes
- Area-based programmes

OREDA under the programme intends to disseminate biomass-based village electrification systems for lighting in two villages of Komna Block, Deodhara and Sinapali. The detailed feasibility report of electrification of village Sinapali, Komna block has been worked out under this report.

2 General information

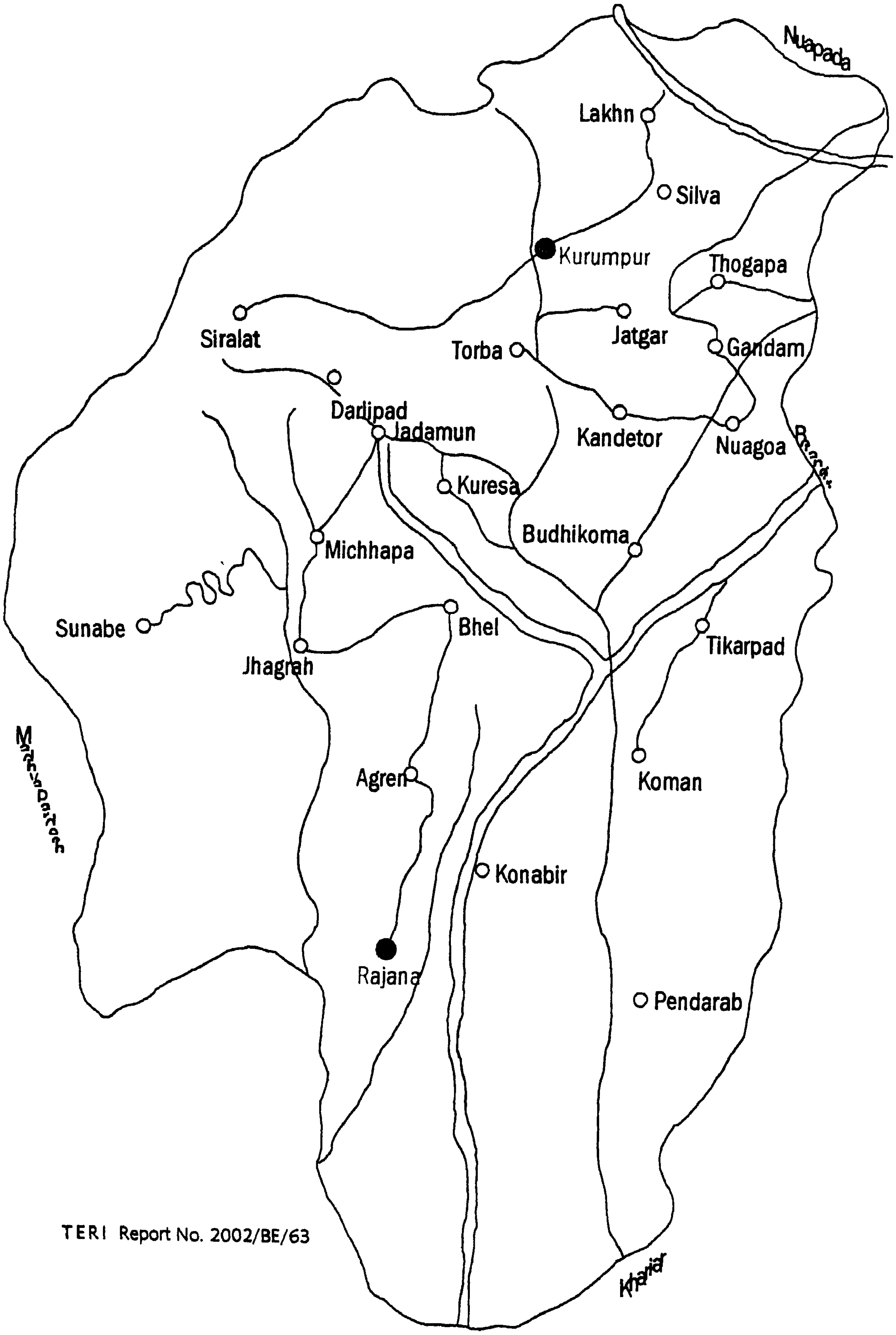
Project area profile

Komna block is one among Nuapara district’s five blocks. The block is situated on north-western side of Nuapara district between parallels of latitude 20°-30’ N and longitude 82° 40’ E bounded by Bolangir district on east, Nuapara block on north and Boden and Khariar blocks on south. On the western side of the block, is Bastar district of Madhya Pradesh. The headquarters of the block is located at Komna on State Highway No.3 at a distance of 38 kms from the district headquarters of Nuapara. Komna block, one of the most backward blocks, has been identified for taking up Integrated Rural Energy Program (IREP) under the Ministry of Non-conventional Energy Sources (MNES). The project area of Komna block is spread over 24 Gram Panchayats, the Block has a population of 13.20% Scheduled castes and 45.33% Scheduled Tribes. About 47.71% of the villages in the block are still un-electrified. The socio-economic status of Komna block is given in the Table 1.

Table 1 Socio-economic status of Komna Block, Nuapara District

Number of Gram Panchayats	24
Number of revenue villages	143
Total Geographic area (in sq.km)	652
Total cultivable area (in ha)	49,100
Total population	104,514
Scheduled castes	13%
Scheduled tribes	45%
Male	50.5%
Female	49.5%
Number of households	21079
Number of rural families	21616
Percentage of rural families below the poverty line (<Rs.11,000 per annum)	89%
Income of Rs.4,000	22%
Income of Rs.4,.000-6,000	35%
Income of Rs.6,000-8,500	22%
Income of Rs.8,500-11,000	9%
Percentage of village electrified up to 1993-94	60%
Literacy rate	19%

Figure 1 Map of the Komna block



The climate of this district, which is in the northeastern corner of the Deccan Plateau is in many respects similar to that on the main Deccan Plateau. The average monthly temperature (minimum, maximum) and rainfall in the area is given in Table 2.

Table 2 Average monthly maximum and minimum temperatures, rainfall (in mm)

Month	Rainfall	Temperature	
		Maximum (°C)	Minimum (°C)
January	-	30.1	11.6
WerFebruary	-	32.8	12.6
March	7.0	37.0	17.4
April	42.0	41.0	20.5
May	18.8	42.7	19.1
June	201.8	41.4	20.6
July	264.8	33.3	19.4
August	256.4	32.7	20.9
September	307.6	32.4	20.0
October	46.0	31.2	16.6
November	-	30.4	14.7
December	-	28.6	12.4
TOTAL	1144.4		

Irrigation facility

There is one medium and three minor irrigation projects in the study area. Also, there are 23 lift irrigation points. 1962 dug wells and 187 water harvesting structures which partly fulfil the irrigation requirements of farmers. Details of the irrigated area in different seasons under different project heads in the study area are presented in Table 3.

Table 3 sourcewise irrigation potential in the Komna block (in hectare)

Block	Medium irrigation projects			Minor irrigation projects			Lift irrigation projects		
	Number	Kharif	Rabi	Number	Kharif	Rabi	Number	Kharif	Rabi
Komna	1	4197	1600	3	316	124	23	304	257
	Dug well			Water harvesting structure					
	Number	Kharif	Rabi	Number	Kharif	Rabi			
	1962	1030	618	187	560	380			

Livestock population

Secondary data sources indicate that the livestock and poultry population are 71706 and 91500 respectively. Bullocks and buffaloes are used as draught animals in agriculture and for carrying goods. Details of the livestock and poultry population are given in Table 4.

Table 4 Bovine population in Komna block (in nos.)

Livestock	Number
Cow	26206
Bullock	37750
Buffalo	7750
Goat	28250
Sheep	15256
Pig	408
Poultry	91500

Demographic characteristics

The number of households in the study area as per 1991 census is 21079. The total population of the study area is 104514. The scheduled caste and scheduled tribe population together accounts for 58.53% of the total population. The scheduled tribes population out numbers that of the scheduled castes by thirty two percent.

3 Village level survey details

To assess the feasibility of a biomass-based gasifier power plant, a village-level survey was carried out. A questionnaire was prepared (Annexure 1) to get information about the electricity requirement of the villagers, the present biomass supply and consumption patterns in the village, costs of different elements, present infrastructural facilities and the willingness to pay. Based on data obtained from the village and household, important operating parameters and individual cost and revenue items are arrived at for analysis. Details of information obtained through the survey are given in the following sections. The gram Panchayat and study village are shown in Figure 2.

Panchayat: KURUMPURI

Kurumpuri	Distance from G.P.H.Q.
Bhojapurghati	6 kms.
Choukapada	2 kms.
Daldali	1.5 kms.
Daimunda	7 kms.
Kusadahan	3 kms.
Latkanpara	3 kms.
Limdihi	1.5 kms.
Mundapal	5 kms.
Sinapali	2 kms.

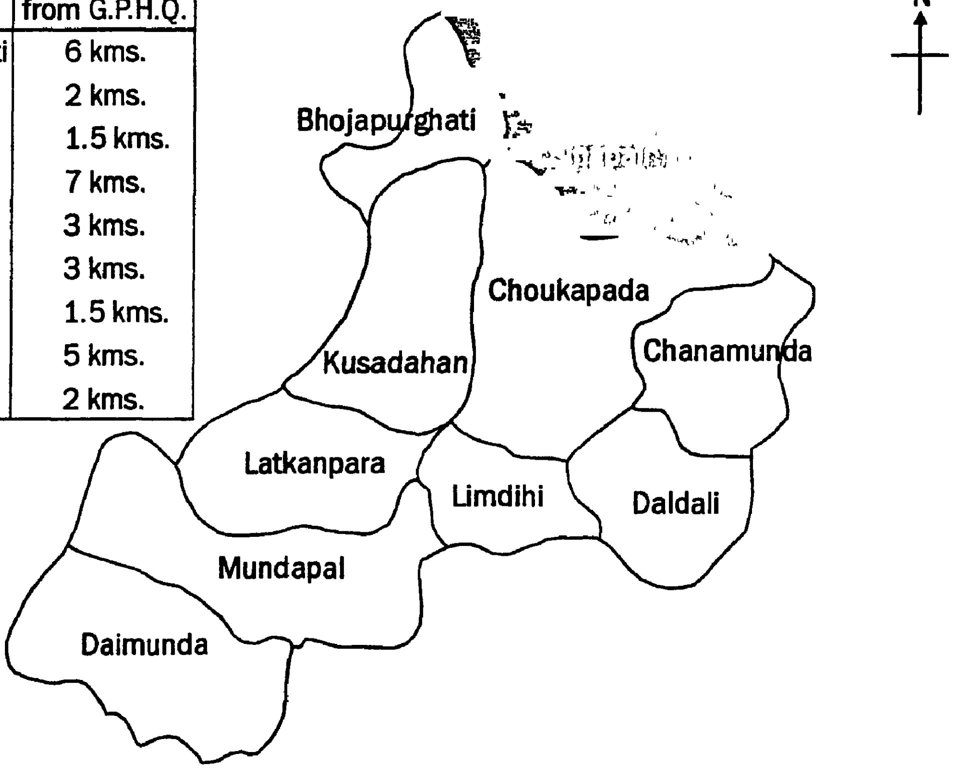


Figure 2 The Kurumpuri gram panchayat

Location and infrastructural facilities

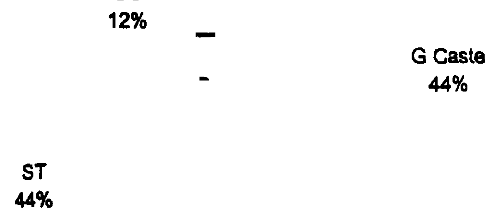
The village Sinapali is located on the northeast of the Komna block and eastern part of Nuapara district. There is a direct road to the study village from the block, districts and state headquarters. From Komna block headquarters the village is 35 km. Regular buses are available upto Komna from Nuapara. The village Sinapali comes under the administrative jurisdiction of Kurumpuri gram panchayat of Komna block (Figure 2). The climate of the area is moist sub-humid, with annual temperature variations ranging from 15°C in winter to 48°C during the summer season.

Primary school level education is available in the study village and facilities for secondary education are available in the district headquarters.

Demographic characteristics

There are 94 households in the proposed study village with a total population of 470. The average family size is 5. Out of 94 households, the majority (44%), are schedule tribes and general caste, and the rest (12%) belong to schedule castes (Figure 3).

Figure 3: Distribution of households by caste composition



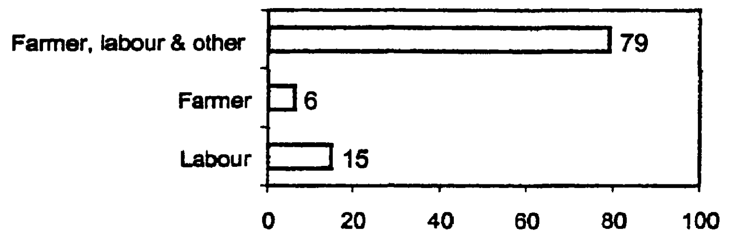
Education

The primary data collected in the study village through detailed survey is on education levels indicates that 40% households are literate among adults and 75% among children, only 15% adults are educated to the middle level and above.

Occupational pattern

The main occupation of most of the households in the village is agriculture, labour and selling of local forest produce. 15% of the total households are agricultural labourers. Figure 4 shows that about 79% of households depend for their livelihood from agriculture, labour and selling of forest produces.

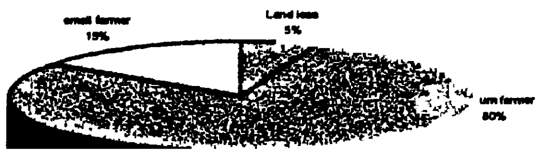
Figure 4 Distribution of households by occupation



Land holding status

The data collected about the present pattern of land holding in the village shows that only one household has land more than 8 acres of land. About 80% households are medium farmers, have between more than 4 acres of land, 15% households have less than 4 acres and the rest 5% are landless. The village level land holding size is given in Figure 5.

Figure 5 Land holding size



Livestock possession

Data collected by the study team on livestock possession of the village is presented in Table 5. It can be seen from the table that the average number of livestock/households is 5. As discussed in the earlier section, very few households are having more than 3 cattle. Only some medium farmers have good number of goats. As discussed above majority of households have less agriculture land poor economic condition. This may be the reason for the low livestock possessed by households in the study village.

Table 5 Possession of livestock by households in the village

Livestock (Cattle)			
Cow	Bullocks	Buffaloes	Goats
220	60	150	300

Source: Primary survey

House type

The data collected on construction and type of houses in the study village, show that all the houses in the village are kucha with thatched tile roofs.

Land-use pattern

It can be seen from Table 6 that land under agriculture accounts for about 58% of the total village land. Over 80% of the village forest areas under tree cover. The village has more than 18% land under the category of barren land. Different trees species are also grown in this category of land. Paddy is the main crop grown in the area. The source of the irrigation is dug wells only. Of the total agricultural land only 2% is irrigated.

Table 6 Land-use pattern in the village

Land category	Area hectare
Total area	361.79
Cultivable land	210.84
Irrigated land	3.84
Forest land	71.63
Waste land	68.39

Source: Revenue inspector, Kurumpun

Energy consumption

Energy consumption is mainly in the domestic sector and the most important energy source is fuelwood. Cooking is the dominant energy end-use. All the households meet their cooking energy needs with fuelwood in the form of logs, branches and twigs. The average, daily consumption of firewood is about 5.6 kg/household in the study village. Most households cook meals twice a day. Rice is the staple food. Kerosene is used mostly for lighting, the monthly consumption of kerosene is about 2 lit/family for lighting. The average energy consumption was calculated on the basis of a survey conducted in study village.

However, the energy consumption pattern of the revenue village was estimated using the survey average and is given in Table 7.

Table7 Fuel consumption in the village Sinapali

	Cooking		Lighting	
	Wood tonnes /day	Wood tonnes /year	litres/month	Litres/year
Fuel wood for cooking	0.526	192.13		
Dung cake	-	-		
Kerosene	-	-	188	2256
LPG	-	-	-	-

Source: Primary Survey

Villagers right under Joint Forest Management[◆]

Under the joint forest management, the rural community should be fully and actively involved in forest protection and conservation. Accordingly, it has been decided that the following schemes involving the rural community will be implemented in the state.

1. The village community, which has taken active part in the plantation and rehabilitation of village forests and in their protection and maintenance under the social forestry project, or have been guarding and protecting forests situated within the boundaries of the village itself. In return the local people would be allowed to collect dry/fallen twigs and leaves, wild fruits, medicinal herbs etc.
2. The local people shall be allowed to obtain fodder grass at comparatively cheaper rates through limited auctions i.e., auctions which shall be confined to the residents of the assigned villages etc.

According the above scheme the household has the right to collect the dry fuel wood and fodder from the JFM managed forest.

Status of biomass resources

Sinapali is predominantly a forest-based village. Besides meeting the domestic biomass needs of the entire household, the forest also provides a subsistence level income to a significant number of families. Additional pressure is in the form of the timber demand of the households. A realistic assessment of the existing stock of woody biomass was carried out to estimate the sustainable yield

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[◆] Office of the Principal Chief Conservator of Forests, Forest Department, Government of Orissa from the growing stock to estimate the surplus wood biomass available for power generation. The methodology for assessment of woody biomass is given in Annexure 2.

Biomass estimation

Inhabitants of these villages have strong link with their surrounding natural environment for fulfilment of their basic requirements as well as to earn their livelihood by selling the forest produce. The sources of biomass include forests, waste or barren land (under cultivation and fallow) cultivation land, pastureland and homesteads. To estimate the quantity of woody biomass on different types of land, six quadrants (100 m × 100 m) were laid in different sites of each classification. Different types of tree species were identified. The girth at breast height (GBH) for sample trees was measured. The heights of trees were measured by the *Abney,s Hand Level*. GBH and height of the trees were used to calculate the volume of the trees. The following equations were used to formulate the regression equation for height and volume (Chaturvedi, 1984)[1]

i) $H = a + b \times G$
ii) $V = a + b \times G^{*}G \times H$ and
iii) $V = a + b \times D^{*}D \times H$

Where V is the volume (in cubic meters), H is height (in m), G is Girth at Breast Height (GBH) (in m), D is diameter at breast height (DBH) (in m), a and b are regression constants.

Woody volume computed in terms of cubic meter was converted to tonnes by the following standard factor:

1.5 cubic meters = 1 tonne

Volume generated by the woody species under different land categories was aggregated to compute the total growing stock in the village. Van Montal's formula (Davis, 1996)[2] was used to calculate the annual sustainable yield:

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[1] *Chaturvedi, A.N., 1984*
Assessment of Biomass Production
Indian Forestor, 110 (8) 726-738

[2] *Davis K P. 1966.*
Forest Management: Regulation and Valuation Ed.II Pub.
McGraw Hill Book Company: pp.110-115

$$Y = \frac{2GS}{R}$$

Where Y is sustainable yield (tonnes/year), GS is the growing stock (in tonnes) and R is the rotation of growing stock in the villages (average 30 years). The average growing stock and sustainable yield is given in Table 8.

Table 8 Total available woody biomass in Sinapali village (tonnes)

Land category	Growing stock (t)	Sustainable yield (t/y)
Agriculture land	2129.48	85.17
Forest land	6665.64	266.62
Barran land	690.73	27.62
Total		379.43

The maximum growing stock on forestland is contributed by miscellaneous tree specious, which were planted between 8to 15 years back. The growing stock from the forest land varies from 78 to 101 tonnes per hectare. The village forest contributes a maximum sustainable yield of 266.62 tonnes (70%) of total yield) per year. Non-forest land (agricultural as well as barren land) also contributes good amount of biomass.

The village forest has different plants species; some common tree species are *Pongamia glabra, Cassin Siamea, Lagerstroemia parviflora, Butea monosperma, Streblus asper, Terminalia alata, Acacia nilotica, Diospyros melanonylon, Acacia leucophlaea, Caloetropia gigantea, Lannea coromandelica, Schleichera trijuga, Terminalia belerica, Acacia actechu, Azadirachta indica, Mitragyna parvifolia, Ectona grandis* etc. Most of the species used as timber while the branches and twigs are used for domestic purposes.

Surplus biomass

In the village the annual sustainable yield is higher than the annual demand of biomass. The total surplus availability of wood biomass from the village is 187.3 tonnes annually. The surplus available is arrived at after deducting the utilization of wood at household (domestic needs) level. This shows that there is enormous scope for biomass-based intervention in the area (Table 9).

Table 9 Surplus annual available biomass in the Sinapali village

Land category	Tonnes / year
Sustainable yield	379.43
Total demand of wood in the village	192.13
Surplus woody biomass in the village	187.3

Willingness to pay for electricity

The villagers were also asked about the possible uses of electricity and the rates they were willing to pay for it. The information is compiled in Table 10.

Table 10 Willingness to pay for electricity

Village	Households	Price that the villagers are willing to pay for electricity for lighting
Sinapali	14	Rs 15/month for single light point for electric supply 6 h/day
	80	Rs 35/month for two light point for electric supply 6 h/day

4

Detailed description of the project

Project information

The project aims to demonstrate a sustainable model for generation and supply of electricity using local biomass resources. The village site proposed for the project is one of the remote/difficult unelectrified villages in the Komna block. The Sinapali village has about 94 households spread over 1.5 km. The proposed project aims to supply electricity to all the households of the village. Initially the project will supply electricity for domestic and street lighting in the evenings. In future, the village may use the power for income generating activities. As per discussions with the villagers the following income generating activities are expected to develop in the area.

1. Bottling unit for packing of honey
2. Leaf cup/plate heating unit
3. Operation of huller
4. Irrigation for vegetable cultivation
5. Pani panchayat
6. Packing unit for forest produce such as amla, trifala etc

The uses of power by these village/cottage industries will increase the capacity utilization of the system, which will help to generate additional revenue for future expansion.

Raw material

The availability of surplus biomass within the village forest is of the order of about 187 tonnes/year, while the biomass requirement for running the 10-kWe output for lighting alone would be bout 20 tonnes/year. Keeping in view the future demand of potential income- generating activities in the village, the power demand of biomass for power generation is expect to grow to 30-40 tonnes/year which can also be met easily within the existing resources.

Raw material collection and processing

In the village, fuel wood is the main source of cooking energy. One member of each family goes to the village forest once in 3-4 days to collect 12-15 kg of firewood. The traditional cook stoves are being used in the village. It is proposed to construct improved smokeless chullas in each household that would save at least 25% of the daily consumption of firewood which would approximately come to about 1 kg and can be meeting the requirement for power generation. In the meeting with the villagers, it was agreed that each household will supply at the plant site about 30 kg firewood/month to operate the power plant. The biomass will be cut to size by the operator in the mechanical cutter supplied along with the system. In the meeting with the villagers and officials of OREDA it was decided that villagers would supply firewood to the power plant free of cost and in return the plant supply electricity for 2 light points per household from 6-10 pm every day. It is advised to form village energy management committee and get the biomass supply formulized.

Working year for system

The system will operate 365 days in a year. It is proposed that the plant will run for about 5 hours (5-10 pm) a day for providing electricity for lighting throughout the year. The first hour of operation will be to stabilize the gasifier operation. The plant's operation may be extended to the morning hours for meeting the power requirements of new income-generating activities. The plant will store sufficient biomass before the start of the monsoon season.

Details relating to size of unit

The capacity of the system is estimated to meet the lighting load requirement of 65 households for lighting 2 points of (40 W). In addition the plant will supply electricity to 10 streetlight points at a common place in the village. Taking this load in consideration the plant size is estimated as follows.

Number of households:	94
Total domestic lighting load @ 80 W/households	7.52 kW
Street lighting loads 10 lights @ 60 W/ point	0.6 kW
Power for woodcutter	1 kW
Total connected load	9.12 kW

In order to meet the requirements of future capacity the technical and distribution losses, the capacity of the proposed power plant is estimated to be 10 kWe.

Output of each unit

The plant will operate from 5 - 10 pm in the evening for domestic lighting. It is also planned to operate a woodcutter of capacity 1 kW from 6-8 pm in order to cut the firewood into the required size. The plant will operate all 365 days for lighting. On this basis, the annual energy generation would come to (94×0.08×4×365) + (10×.06×4×365) kWh or 11855 kWh. Plant repairs and maintenance will be carried out in the daytime and hence no shut down is expected during normal operation.

Technology, system design, specifications and financial details of the project

Technology description

The block diagram of a biomass based power plant for village electrification is shown in Figure 6 and explains the working arrangement of the system. Biomass is fed into to the hopper of the gasifier, which is provided with a door opening arrangement using the water seal concept. The opening and closing of the door is possible using a manual chain pulley device. The cold starting and stabilization of the gasifier system will require one hour of operation and can be done with an integrated biogas engine. The biomass is converted into gaseous fuel called producer gas through the partial combustion route in the gasifier reactor. The gas is drawn below the grate and allowed to pass through the cleaning system. The ash from the gasifier falls into the ash pit, which is filled with water and acts as a water seal. The hot combustible gas coming out of the gasifier carries impurities such as dust particles and tar vapours, which can be cleaned in the cleaning train before being supplied to the engine. A cooling and cleaning train will cool and clean the gas upto the prescribed MNES standards.

The cooling and cleaning train involves a gravity filter/heat exchanger-cum-SS mesh filter, to remove the larger particles. Packed bed scrubber and centrifugal scrubber are placed to remove the tar and fine particles. A mist separator is used to remove the entrained particulate carried away by the gasses when the gases are cleaned in the wet scrubber. A paper filter is used as a safety filter to ensure that the gas contains permissible levels of tar and dust. The gas and air mixture is introduced at the air intake of the engine to supply it through a manifold. Valves are provided both for the air and the gas in order to obtain the optimum mixture.

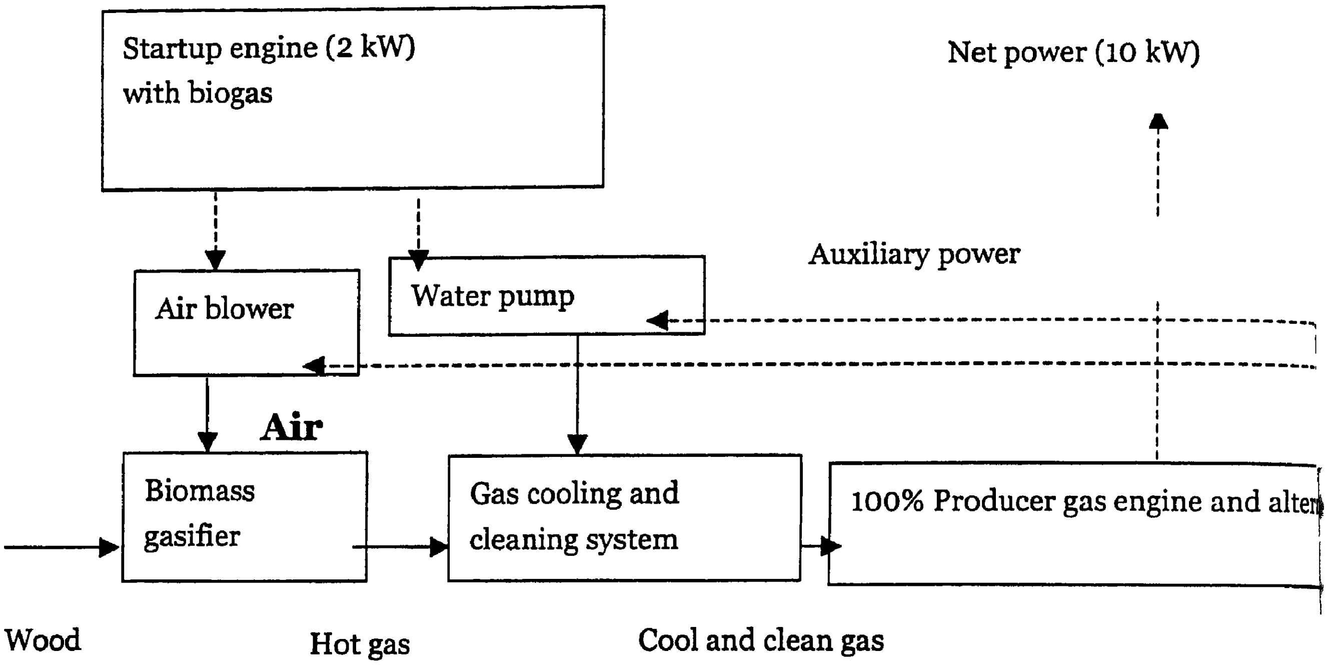


Figure 6 100% Biomass gasifier-based decentralized power generation system

System configuration and design

Gasification process

Gasification is the conversion of a solid biomass fuel into a gaseous fuel. A combustible gas with a heating value of 1000 – 1200 kcal/Nm^3 is produced The composition of producer gas obtained from the gasifier on volumetric basis is given below:

Carbon monoxide	CO	18-24%
Hydrogen	H_2	13-20%
Methane	CH_4	1-3%
Carbon dioxide	CO_2	12%
Nitrogen	N_2	Balance

Acceptance feedstock

The Gasifier should be suitable for operation with woody biomass.

Gas cleaning system

The hot gas obtained from the gasifier, contains particulates and tar as impurities. The tar and particulates are removed before the gas is supplied to the engine. The cooling and cleaning train has the following subcomponents:

Heat exchange-cum-hot filter

The hot gases coming out of the gasifier are allowed to pass through an air gas heat exchanger where hot gases are allowed to pass over a series of tubes carrying ambient air. In the process the ambient air gets heated by the gases. The hot air from the heat exchanger is then supplied to the gasifier. As a result of supplying hot air instead of cold air the gasifier reactor temperature increases which helps in get the tar crack within the reactor. The filter is designed that the gas velocity is reduced to less than 0.01 m/s which will allow the heavier particles carried by the gas to get separated by gravity. The gases will then pass through an SS wire mesh, which separates dust particles upto 40 micron in size from the gases. Finally the gases are allowed to pass through an asbestos fabric filter.

Cyclone filter

In stage 2 the hot gases are passed through a cyclone. The high velocity and the tangential entry into the filter creates a centrifugal motion in the cyclone's gas which in turn, separate the dust particulates present in the gas and get collected in the ash pit. Most of the particulates in the gas get separated at this stage.

Packed-bed scrubbers

The gases coming out from the cyclone will be allowed to pass through the packed bed scrubber. In this scrubber the counter flow of gas and cooling medium (water) will helps to cooling the gas and remove tar. The contact area of gas and water is increased by putting a stationary bed of rasching rings. The gas inlet is at the bottom of the scrubber and water is sprayed from the top. The clean gas is taken out from the top of the filter. The sprinkled water drips into the ashpit that is re-circulated.

Centrifugal scrubber

The gas coming out of the packed bed scrubber is allowed to pass through a centrifugal scrubber. The centrifugal scrubber consists of a suction blower with a chamber at the inlet. Water at high speed is supplied to this chamber. The water and gas mix thoroughly while passing through the blades of blower. The turbulence action in the scrubber allows water to carry away some heavy tars from the gas. During this process some water particles which get carried away by the gases justify the use of a mist separator.

Mist separator

The gas coming out from the centrifuge scrubber still contains water and tar in the form of mist and vapour. The mist separator is designed to remove the mist from the gas. The moisture is removed from the gases by the centrifugal motion of the gases within the mist separator.

Fabric filter

The gases coming out of the mist separator are allowed to pass through a fine fabric filter.

Paper filter

A paper filter is used to ensure that no tar and dust enters the engine. This also acts as a safety filter for the engine, increase the life of the engine, and provide ease of maintenance.

Technical specifications of biomass gasifier-based power plant

Gasifier

Capacity of the gasifier	Suitably rated for operation with a diesel engine of capacity BHP 26 coupled to an alternator of capacity 20 kVA
Material to be used for fabrication	The gasifier is made of MS lined with refractory castable
Average calorific value	1000-1200 kcal/Nm^3
Biomass consumption	1.4 kg/kWh (woody biomass)

Biomass feeding interval for Batch operation (minimum)	Not less than 5 hours
Starting and stabilizing time	less than 10 minutes and 30 minutes
Starting method	Biogas plant coupled with a biogas engine is used for producing starting power
Filtering arrangement	Two-tier hot air entry arrangement for ensuring tar cracking in the reactor Hot filtering for particulate removal and water scrubber for tar removal and fine filter provided to ensure tar-free clean gas to engine
Painting of all gasifier systems	All exposed steel/iron parts of the gasifier system shall be suitably painted.

Other details

Type of filter material	SS wire mesh filter/asbestos fabric polypropylene
Filter material life	1000 h (minimum)
Minimum permissible	a) Tar content: 100 mg/Nm^3 b) Particulate: 50 mg/Nm^3
Interval of cleaning	50 hours (minimum)
Cooling system	The gas temperature at the engine inlet will not exceed 50°C

100% gas engine

Type of cooling	Water-cooled engine as per relevant IS Standard with rated speed not more than 1500 RPM

Number of cylinders	2
Bore and stroke	114.3 mm × 116 mm
Rated power of the engine	26 BHP at 1500 RPM
Type of control	Manual
Starting system	Battery starting with automatic battery charger
Battery	Battery should be of reputed make and guaranteed for a period of 24 months from the date of commissioning.

Blower

Type and capacity	Centrifuge, 0.375 kW

Alternator

Make	Crompton/Kirloskar/some other standard company
Speed in RPM	1500
Voltage	415 Volts
Frequency	50 Hz
Number of phases	3
Power factor	0.8
Duty rating	26 BHP
Type of insulation	F-Class
Rating	20 kVA

Pump

Capacity	0.75 kW
RPM	2800
Make	Sharp
Type	Single phase 240 V

Control panel

Brief details of the Control Panels are given below:

Panel dimensions	1 m × 0.5 m
Meters provided	Voltmeter with selector switch Ammeter MCB Indicators Frequency meter

Specifications of the meters

Meter	**Range**
Voltmeter	0-500 V
Ammeter	0-30 A
Frequency meter	45-55 Hz
MCB	20 A with TPN (triple pole with neutral)

Name plates	Engraved nameplates shall be furnished for each panel.

Gasifier for control panel

Indicator	Indicators related to operation of blower, pumps, vibrator motors, temperature.

Earthing

The earthing system shall be designed as per the standard practice.

Wood cutter

Type	Hand fed, hand operated, counter weight type with safety guard
Capacity	100 kg/h, woody biomass, upto 100 mm
Type of cutter	Rotary disc High carbon steel
Motor	1 phase induction motor

Transmission and distribution system

The details of local distribution network are

Cable	Arial bunched
Wind pressure	75 kg/m^2
Working load	140 kg
Type of poles	8 m long PSCC
Number of poles	16 per km
Span	65 m
Size of conductor	3 × 16 +25 sq-mm

The layout of the local distribution network for the village is given in Annexure 3.

Power station complex

Building for biomass gasifier and the engine

The power plant building will be located in the load centre of area 36 m^2 (only equipment space). Power will be supplied to the consumers directly from generator to 415/230 Volts. This building will be used for housing one 20-kVA generating set along with the biomass gasifier and the associated equipment. The building will have a steel truss roof with a CGI sheet cover supported on RCC columns. The outer wall will be made of CGI sheet fitted on a suitable frame or first class brick without any surrounding wall. There should be free movement of air because carbon monoxide is a constituent of producer gas and it is injurious to health. The producer gas cannot be liquefied or bottled easily and needs a pipeline of large diameter for conveying it to distant places due to low energy content. For best results the gas should be consumed near the point of generation and for this reason the gasifier building should be located as close to the main plant building as possible.

Covered store for biomass

A covered warehouse will be required for storing fuel for a minimum one month and cutting of biomass during rains.

Cooling/cleaning water

Cooling/cleaning of gas is based on water and while it is largely re-circulated, a very small quantity of make-up water is needed.

Safety considerations

The gas produced by gasifier contains carbon monoxide, so the entire gasifier installation shall be kept in an open shed.

Capital costs

The unit is estimated to be 10-kWe output and plant and machinery cost of the plant is given in Table 11.

Table 11 Project cost : 10 kWe biomass based power plant

Description of Items	Quantity	Amount in Rs
Biomass Gasifier, 10 kWe capacity	1	120000
Cooling and cleaning systems	1	150000
Diesel engine, 15 kVA capacity	1	120000
Modification of engine	1	75000
Starting kit	1	75000
System transportation	1	50000
Local grid and distribution system	1 km	200000
Site preparation, erection works	525 sq-ft shed area 225 sq-ft building area	225000
Installation and commissioning	1	50000
Biogas engine, 5 KVA capacity	1	50000
Biogas plant (4 m^3) for initial starting of gasifier	1	30000
Total		1145000

Item Nos 7, 8 and 11 are under scope of OREDA

Project financial details

The total project cost is estimated to be about 17,20,000 rupees and the cost break-up under different heads are given in Table 12.

Table 12 Cost break-up under different heads

Description of Items	Amount in Rs
Capital equipment	1145000
Trials test run at Gual Pahan for two months	75000
Travel and per diem cost:	
Technician (1 persons, 3 trips)	75000
Professional (1 person, 2 trips)	125000
Annual maintenance* @50,000/yr X 3 yr	150000
Training (total four modules two at Gual Pahan and two at actual site)	150000
Grand Total	1720000

Source of Fund

The complete cost of the project covering capital cost of system, its accessories, local distribution network, training cost, repair and maintenance costs for three years and consultant costs will be borne by the OREDA.

Operating statement of plant

Each household (beneficiary) shall provide minimum of 30 kg of firewood per month basis required to run the plant. The villages shall on a contributory basis provide the raw material for biogas digester. In addition to raw material supply, the beneficiary community shall also contribute 30 rupees/month for maintenance of the biomass based gasifier system. All such contributions are to be fixed/revised/collected and monitored by the EMC or authorized personnel. The basis of different costs elements are given in Table 13.

As seen in the Table the net annual revenue from the plant operation will be 33,840 rupees against the total annual operation expenditure of 37,200 rupees. In order to sustain the operation of the system. It is proposed that out of the total annual interest income earning of 32400 rupees by the EMC from the seed capital fund, the costs of plant operators will be met i.e. 19200 rupees. The costs of repair and maintenance of the plant will be met through the sales income. As a result a surplus revenue of 15,840 rupees will be generated which will be kept under the reserves. The project implementation plan is given in Annexure 4.

Table13 Basis for deriving different costs elements of operating expenses

ITEM	DETAILS	AMOUNT (Rs) (Annual)
Sales	Net income by sales of electricity is taken as Rs 30/month/HH/for domestic lighting	Rs (30×94×12) = Rs 33840
Raw material consumption	The specific biomass consumption per unit of electricity produced is about 1.4 kg/kWh and the cost of biomass required for gasifier operation is taken as nil since the villagers will supply the biomass to the plant free of cost. The cutting of biomass into required size will be carried out by the operator.	Nil
Direct Labour	One trained operator @ Rs 1000 per month and helper @ Rs 600 per month to overlooks all operations of the plant.	Rs. 19200
Repair and maintenance	It is assumed that the main operator will do the daily maintenance of the system. The scheduled repair and maintenance of gas engine will be carried out by the authorized service centre of the engine. About Rs 1500 per month is kept for repair and maintenance of the gasifier system including the filters and oil.	Rs 18000

Requirement for sustainable operation

Name of the organisations jointly participating in the project and its roles

OREDA

OREDA is the lead agency for implementation of the project and is responsible for

1. Formation of Energy Management Company both at the Grama Panchayat and Village level
2. To provide Seed Capital fund of Rs 4,00,000 (Rupees four lakhs only) to EMC for meeting the expenses towards up keep, operation and maintenance.
3. District officer will look the overall the supervision of the system
4. To provide capital for complete project
5. To maintain an office at Komna which will be managed by 1 junior project engineer and 2 technicians who shall be responsible for upkeep of community systems of the block

Kurumpuri Grama Panchayat

Grama Panchayat will form an Energy Management Committee (EMC) having representatives of Villages, Block Development Officer (BDO) Sarpunch of Grama Panchayat, and OREDA. The main responsibilities of the EMC are

1. To manage Seed Capital Fund and to provide funds to Village Energy Management Committee (VEMC) for operational and maintenance of the systems.
2. To engage trained persons for the operation, maintenance and upkeep of the system on a mutually decided salary
3. To operate, maintain and upkeep of the gasifier-based system to be installed in a sustainable manner through community participation

Village Energy Management Committee

The villagers of the beneficiary village will form a Village Energy Management Committee (VEMC). It is proposed that the VEMC will have nine members from the respective village with one-year term. The main tasks of VEMC are:

1. Meet at least once in a month to review payment receipt, supply of raw materials and operation of the plant.
2. To engage trained persons required for the operation, maintenance, and upkeep of the system
3. To supervise the operation of the system
4. To provide the panchayat land for the installation of gasifier-based power plant

Tata Energy Research Institute, (TERI)

TERI will be the technology consultant for the project. TERI will be responsible for finalizing the system configuration, system component design, and fabrication, erection, commissioning and training of operators for sustainable operation.

Divisional Forest Officer (DFO)

Under the present situation the biomass required for operation of the system is sustainable available from the village forest. However, to ensure the long term sustainability of the biomass supply for the system it is proposed to bring an additional 25 acres of village land under energy plantation (rotation plantation) through the divisional forest office. The funds require for such an activity will be made available from the project to DFO.

Creation of an EMC

OREDA will have to form an EMC (Energy Management Committee) in the Kurumpuri Gram Panchayat of the proposed project area consisting of the following members:

1. Sarpanch
2. Panchayat samitee member
3. Representative of the village where community system has been installed
4. Block development officer
5. Officer of OREDA

It is proposed that EMC should ordinarily meet once a month, review the functioning of the system(s) and other related matters and if necessary pass suitable resolutions for taking up repair/maintenance work as the case may be. The officer of OREDA will act as the authorized officer as well as the drawing and disbursement officer for the EMC. It is proposed that OREDA would also deploy its technicians for overall management and maintenance of the system.

It is proposed that OREDA to maintain an office at Komna managed by 1 junior project engineer and 2 technicians who shall be responsible for the upkeep of community systems of the block. In this case the upkeep of the systems can be ensured for a minimum period of 10 years.

Revenue management

The authorized staff of the VEMC shall be responsible for collecting and maintaining records for monthly payment and firewood collection from the beneficiaries. The revenue will be deposited in the VEMC accounts. The fund required for repairs and maintenance of the system can be withdrawn from the account by authorized persons of VEMC. The signatures of two persons of VEMC and one from OREDA official should be made compulsory.

Every effort should be made to maintain transparency in accounting and management, as it is very essential to gain the confidence of the people and manage efficiently.

Economic and social aspect at present and after implementation of the project

1. It is excepted that the socio-economic activities of the village will increase after commissioning of the system
2. Socio-cultural activities will increase as power will be available in the evening.
3. The project will give an opportunity for village children to read in the evening

4. The income generating activities through the use of available power should be encouraged to start small village/cottage industries, agricultural and commercial activities and this will result in overall development.

Direct and indirect benefits

Direct benefits

a. This will provide power to village Sinapali G.P Kurumpuri village area.
b. The power plant and the energy plantation will open new avenues of income generation and employment generation for local people.
c. This will provide opportunity for farmers to use this power for irrigation
d. This will help in overall development of the village
e. This will help in becoming model for other villages

Indirect benefits

a. Development of village/cottage industries in the area
b. Villagers will have get better infrastructural facilities which depend on power
c. Children will get the opportunity to study

Manpower training

Organization for operational maintenance

OREDA will hand over the plant to the Village Energy Management committee after commissioning. The VEMC will be formed with the active participation of the local people and the Village panchayat. TERI will provide training on the technical, operation, and maintenance aspects of the system to a team of three to five persons consisting of a representative of OREDA, and operators selected by the VEMC. In order to provide effective training to the team it is proposed to conduct it at two levels. In stage one, the team will be trained for 15 days at Gual Pahari where both elementary and technical aspects of the technology/system will be given. In addition the team will also be trained about the operation and maintenance aspects. At the second level the team will get be trained about the erection, commissioning aspects of the system along with its O&M for regular operation.

Annexure 1: Feasibility Study on Popularization of Oil-Replacement Energy in Orissa

Tata Energy Research Institute, New Delhi

Village check list

1. General information	**1.**	**2.**
Name of the village		
Name of the revenue village		
Gram Panchyat		
Block		
2. Household and village detail		
Total households		
General caste		
ST family		
SC family		
BPL family		
Average family size		
Percentage of literacy		
Average family income		
Distance from the nearest power line		
Distance from metalled road		
Distance of nearest petrol pump		
Distance from Block headquarters		
3. Land classification (From the RI /Panchayat Office)		
Forest land (ha)		
Net cultivable land (ha)		
Irrigated land (ha)		
Un-irrigated land (ha)		
Fallow land (ha)		
Barren land (ha)		
Pasture land (ha)		
Cultivable waste land		
Other land (ha)		
Total land (ha)		
4. Land holding Size (HH):		
Large farmer >10 acre		
Medium farmer 5-10 acre		
Small farmer 2.5-5 acre		
Marginal farmers <2.5 acre		
Landless		

Annexure 1. contd

5. Livestock population (Nos)				
Cows				
Bullocks				
Pigs				
6. Biomass production detail-2000	**Area (ha)**	**Yield q/ha**	**Area (ha)**	**Yield q/ha**
• Paddy • Millet • Ragi • Sugarcane • Any other crop				
Forest area under tree cover (ha)				
Production (per hectare)				
Area under shrubs (ha)				
Area under social forestry				
Production (per hectare)				
7. Biomass supply details				
Distance covered for wood collection (km)				
Weight of head-load (kg)				
Trips made/week /family				
Families selling wood				
Wood sold in (Kg/Week)				
8. Fuel Distribution Pattern				
Usage of wood				
Usage of dung cakes				
Usage of kerosene				
Usage of diesel				
Usage of crop residue				
Cooking (%)				
For thatch (%)				
For cattle feeding (%)				
Remaining surplus CR (%)				
9. Cost of Available Biomass/Fuel				
Wood (Rs/bundle)				
Paddy residue(Rs/Quintal)				
Millet residue(Rs/Quintal)				
Kerosene (Rs/litre)				
LPG cylinder (Rs)				

Annexure 1. contd

Diesel (Rs/Litre)		
10. Water Supply		
Source of water		
No. pumpsets for water supply		
Type (diesel/kerosene)		
Capacity		
Fuel consumption per hour		
No. of hours and time used/day		
Distance from the village to site		
11. Other information		
Labour cost-general (Rs/day)		
Agriculture labour cost (Rs/day)		
12. Transportation availability		
Tractor- rate Rs/day		
Bullock cart Rs/day		
By head load (Rs./day)		
13. Lighting Requirement and Uses		
Uses of light		
Monthly expenses for home lighting per family		
Lighting devices		
Requirement of better light?		
Purposes of better light		
14. Willingness to spend for better lighting		
Beneficiary share for one point (Rs/month)		
Beneficiary share for two point (Rs/month)		
Beneficiary share for other use (Rs/month)		
Required no. of points in villages		
Lighting hours required/ day		
Load Required for pumping		
Pump running hours/day		
Total load required		
15. Economic activity (lighting options)		
Income generating activities		
Fair price shop (no. of points required)		
Primary school (no. of points required)		
Community Hall (no. of points required)		
Primary Health Center (no. of points required)		
Flour mill (load)		

Annexure 1. contd

Diesel consumption per day–litres		
Rice mill (Load)		
Diesel consumption day–litres		
Oil processing (load)		
Smithy (No. of points)		
Fuel used per month		
16. Institutions		
Present gram panchyat and activity in the village		
Cooperative society and activity		
Are they interested in managing the gasifier and how		
Possible income generation activities for electrification	1 2 3	1 2 3

Annexure 2. Calculation of sustainable yield of woody biomass

Woody biomass

Different types of tree species were identified. The girth at breast height (GBH) for sample trees was measured. The height of trees were measured by the *Abney,s Hand Level*. GBH and height of the trees were used to calculate the volume of the trees. The following equations were used to formulate the regression equation for height and volume (Chaturvedi, 1984).

i) $H = a + b \times G$
ii) $V = a + b \times G * G \times H$ and
iii) $V = a + b \times D * D \times H$

Where V is the volume (in cubic meters), H is height (in m), G is Girth at Breast Height (GBH) (in m), D is diameter at breast height (DBH) (in m), a and b are regression constants.

Woody volume computed in terms of cubic meter was converted to tonnes by the following standard factor:

1.5 cubic meters = 1 tonne

Volume generated by the woody species under different land categories was aggregated to compute the total growing stock in the village. Van Montal's fomula (Davis,1996)[•] was used to calculate the annual sustainable yield:

$$Y = \frac{2GS}{R}$$

Where Y is sustainable yield (tonnes/year), GS is the growing stock (in tonnes) and R is the rotation of growing stock in the villages (average 30 years).

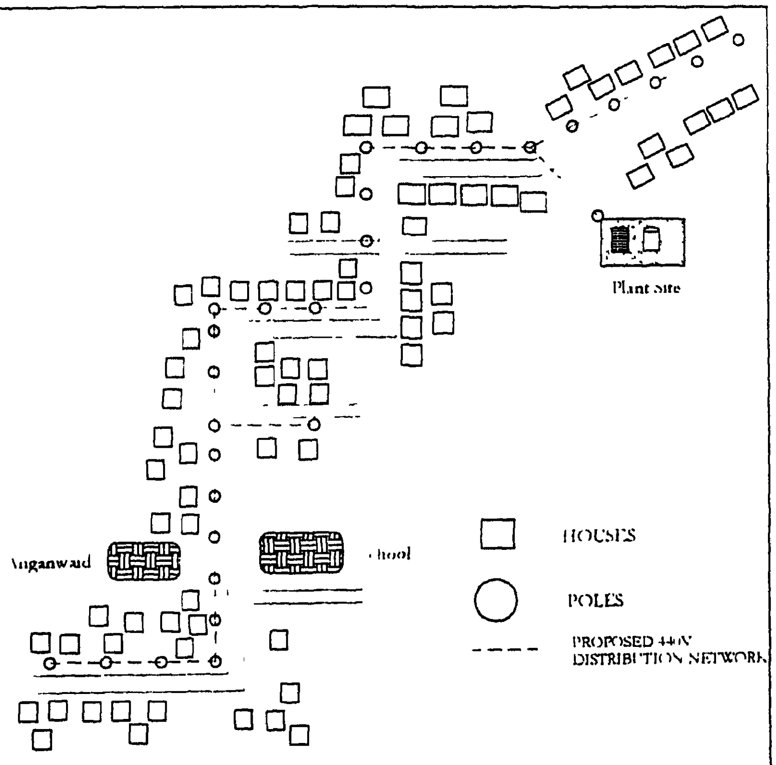
Shrubs

To estimate the biomass from the different areas, three quadrates, 10 m ×10 m were laid in different sites. The growing stock is calculated using a regression equation. The average growing stock is 101.63 tonnes/hectare and sustainable yield 6.7 tonnes/hectare. The method was adapted to estimate the shrub biomass from different area, so the GS of *Lantana* is 0.8 tonnes/hectare.

[•] Reference:

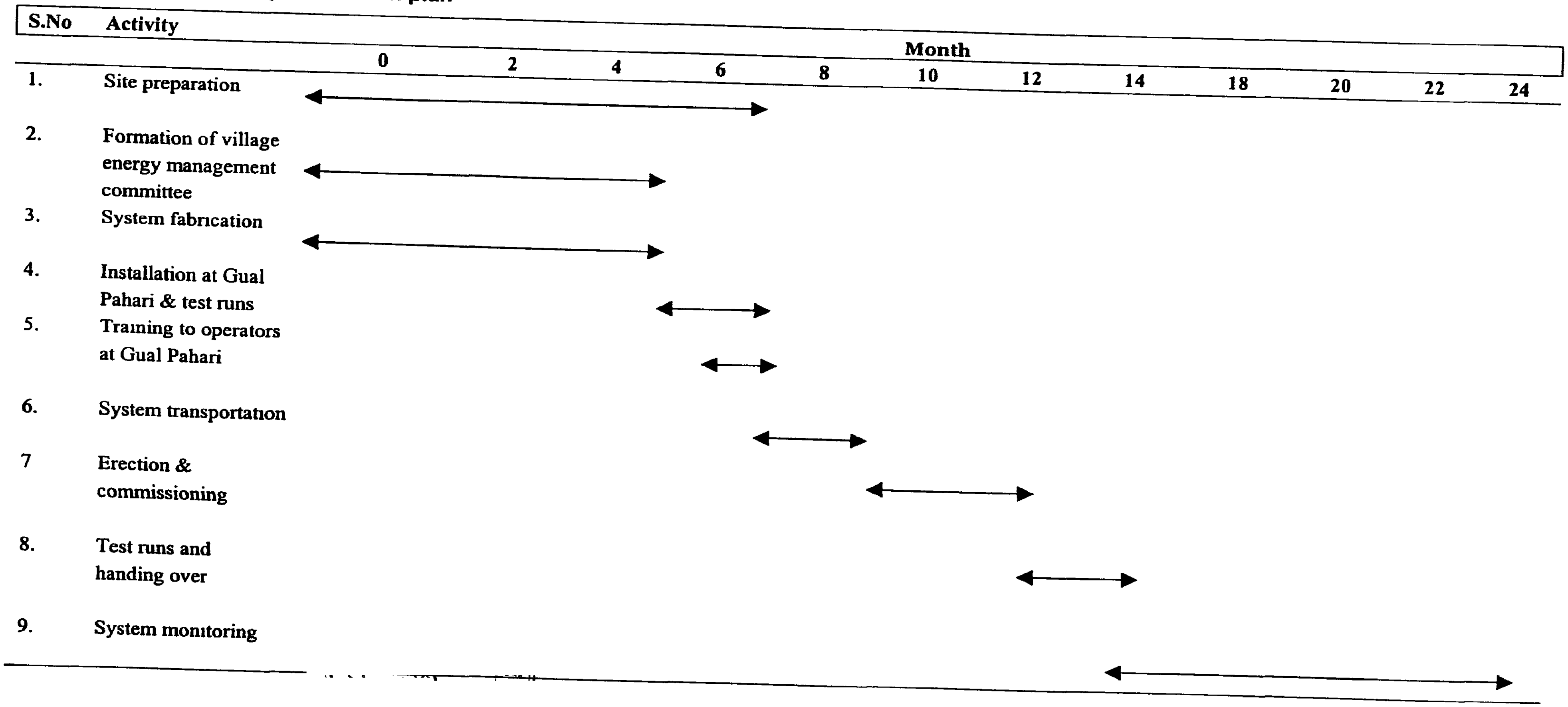
Chaturvedi, A.N., 1984	Davis,K.P. 1966.
Assessment of Biomass Production	Forest Management: Regulation and Valuation Ed. II Pub.
Indian Forester, 110(8) 726-738	McGraw Hill Book Company. pp. 110-115.

Annexure 3



VILLAGE ELECTRIFICATION PLAN OF SINAPALI KURUMPURI G.P SITE MAP

Annexure 4: Project implementation plan


S.No
Activity
Month
0
2
4
6
8
10
12
14
18
20
22
24
1. Site preparation
2. Formation of village energy management committee
3. System fabrication
4. Installation at Gual Pahari & test runs
5. Training to operators at Gual Pahari
6. System transportation
7 Erection & commissioning
8. Test runs and handing over
9. System monitoring